

*Observations of
Supersaturation near the
Tropical and Sub-Tropical
Tropopause*

CRYSTAL-FACE July, 2002

Outline:

- **Motivation:**

Why Measure Water and Relative Humidity?

- **Measurement:**

Accuracy of Water Vapor & Temperature

- **Observations:**

Supersaturation Frequently Observed in the Upper Troposphere

- **Future Work:**

Missions to Tropics

Case Studies in C-F data set

Motivation:

Why Measure Water and Relative Humidity?

These Measurements are Critical to Understanding the Following:

- Mechanisms of Dehydration in the Upper Tropical Troposphere (UTT)
- Microphysics of Ice Nucleation & Cloud Formation
- Water Vapor Trends in the Upper Troposphere/Lower Stratosphere (UT/LS)
- Radiative Impact of Water & Clouds in the UT

Measurement:

The Importance of Accurate Temperature and Water Vapor Measurements.

Relative Humidity with Respect to Ice (RH_i) is a function of ambient Water Vapor, Temperature and Pressure.

$$\text{RH}_i = \text{H}_2\text{O} / \text{SMR}_i$$

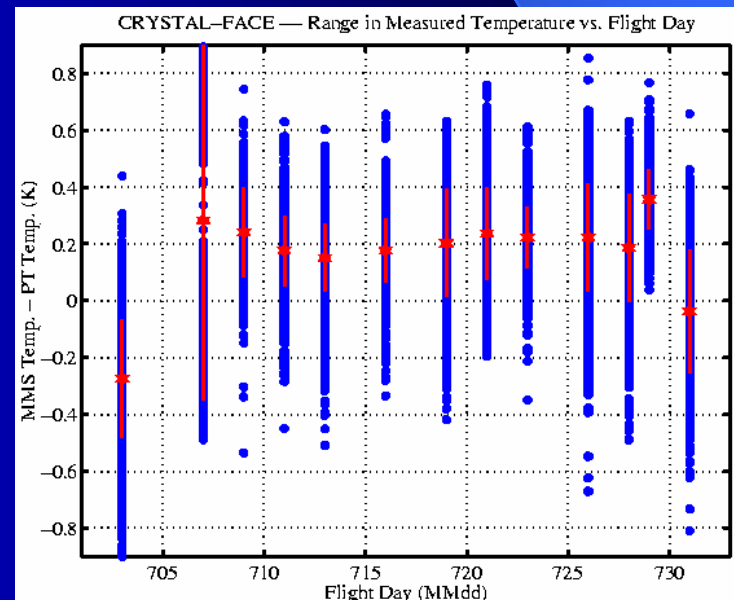
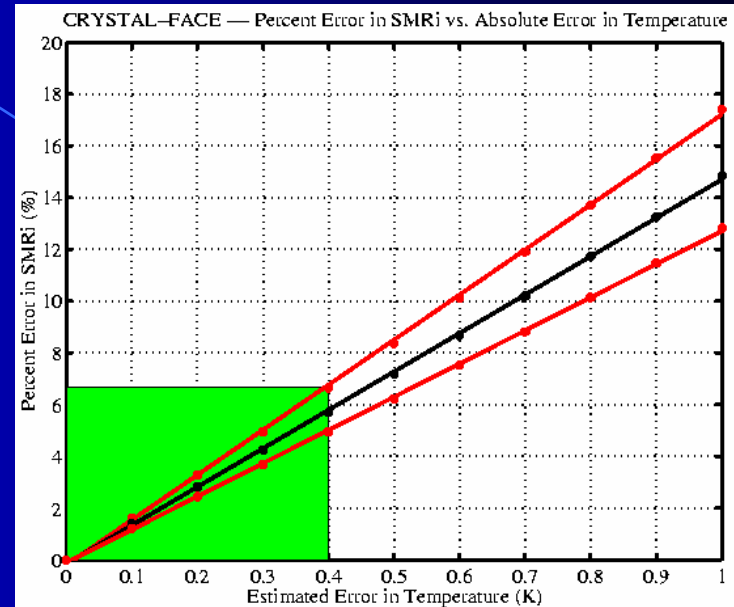
→ Accuracy of RH_i depends upon accuracy of Water Vapor and SMR_i

$$\text{SMR}_i = \text{fn}(\text{Temperature})$$

→ Accuracy of SMR_i depends upon accuracy of measured Temperature

Temperature

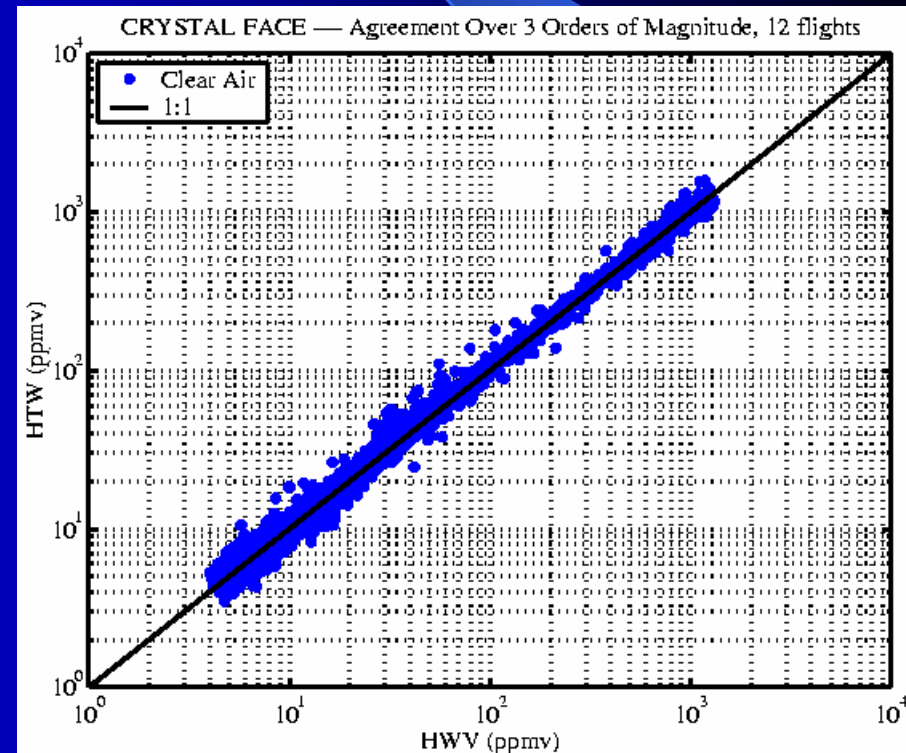
- At a given T & P (210K, 125 mbar), the error in SMRi grows linearly with uncertainty in temperature.
- $\pm 0.1\text{K} \rightarrow \sim 1\%$
 $\pm 0.5\text{K} \rightarrow \sim 8\%$
 $\pm 1.0\text{K} \rightarrow \sim 15\%$
error in SMRi.
- MMS typically measures 0.2K warmer than TPT, yielding a 3% higher SMRi.



Water

Accuracy of Harvard Water Vapor

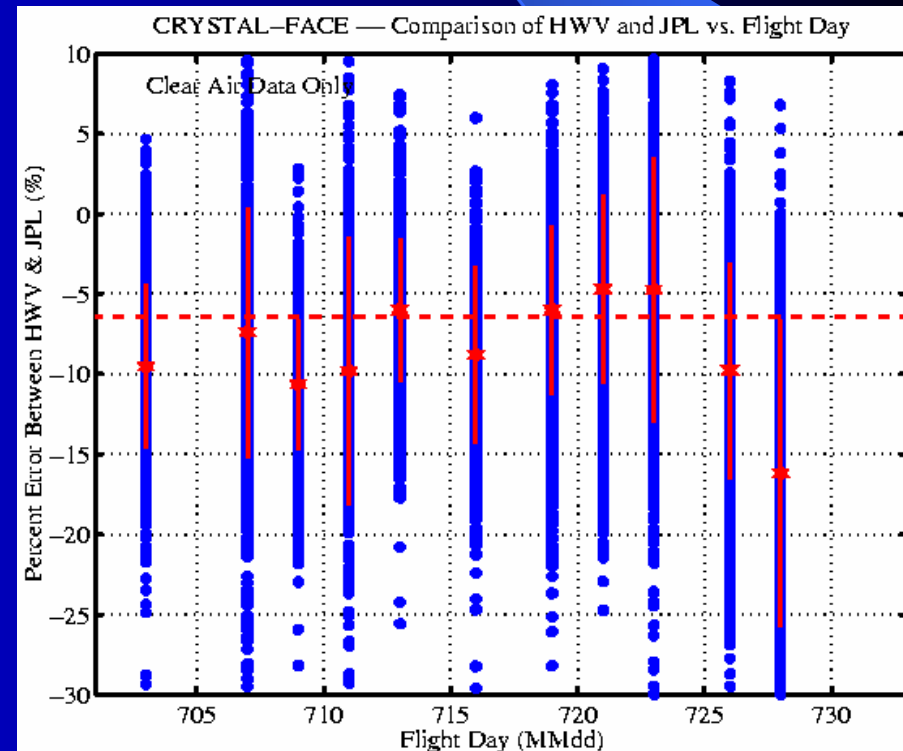
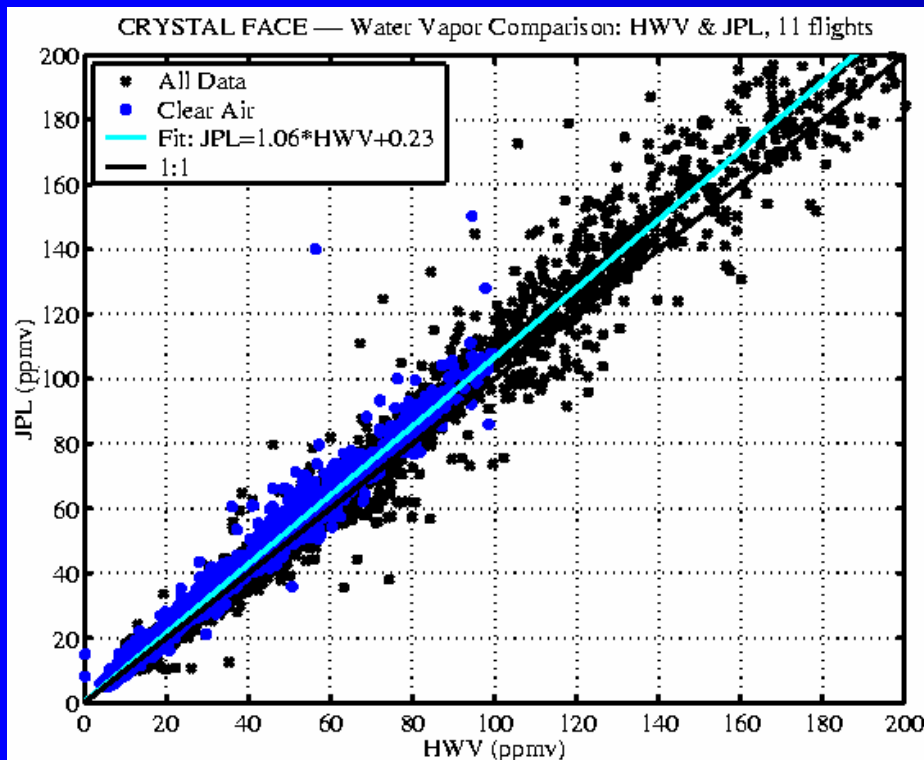
- We calibrate over a range of pressures (50–150 mbar) and water vapor mixing ratios (10–200 ppmv), and expect the accuracy of the calibration to be good to $\pm 5\%$.
- We performed numerous calibrations of both HWV and HTW in the field.
- HWV & HTW show agreement over three orders of magnitude.



Water

Comparison with JPL Laser Hygrometer

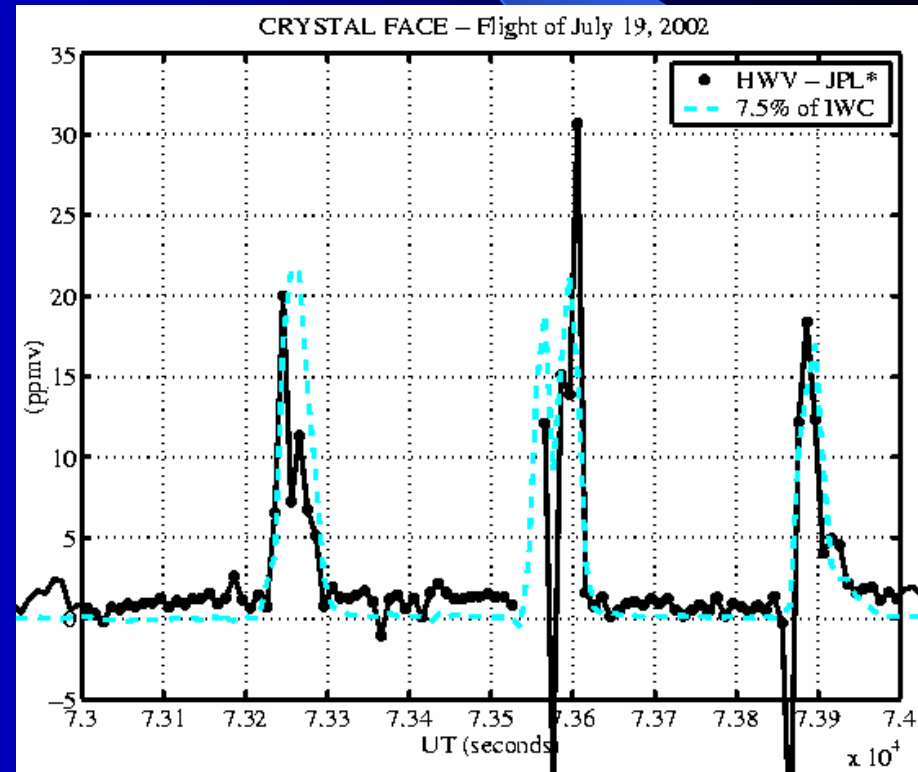
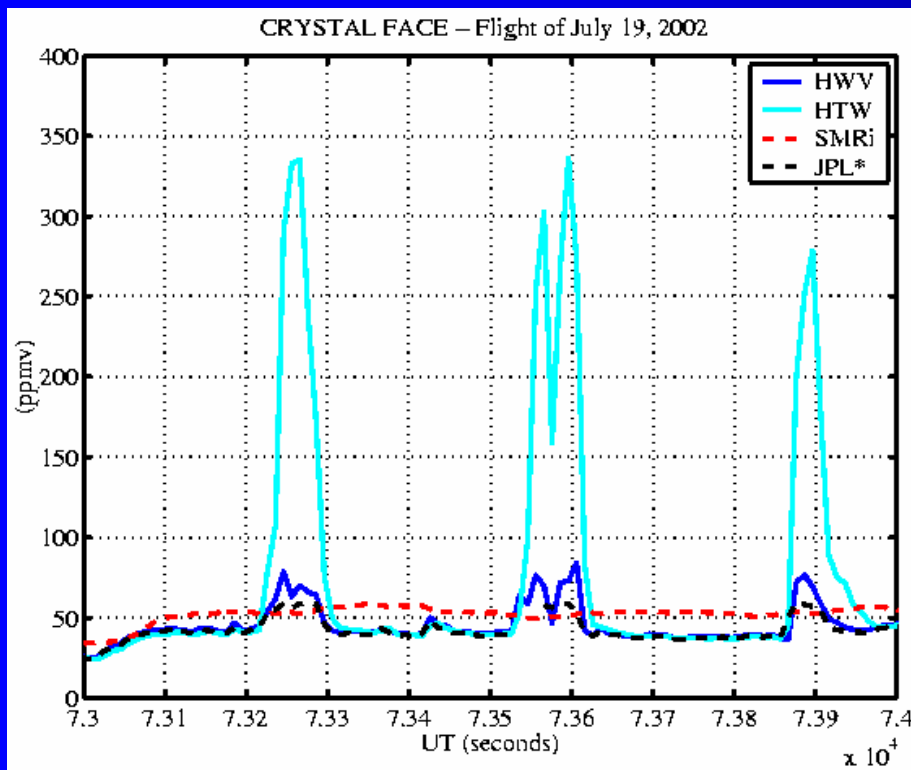
- In the UT the instruments agree to within $\sim 6\%$ $\pm 5\%$, with JPL measuring higher.
- The combination of Harvard Water and MMS currently provide the lowest estimates of RH_i.



Water in Clouds

Contamination from Sublimation in HWV duct

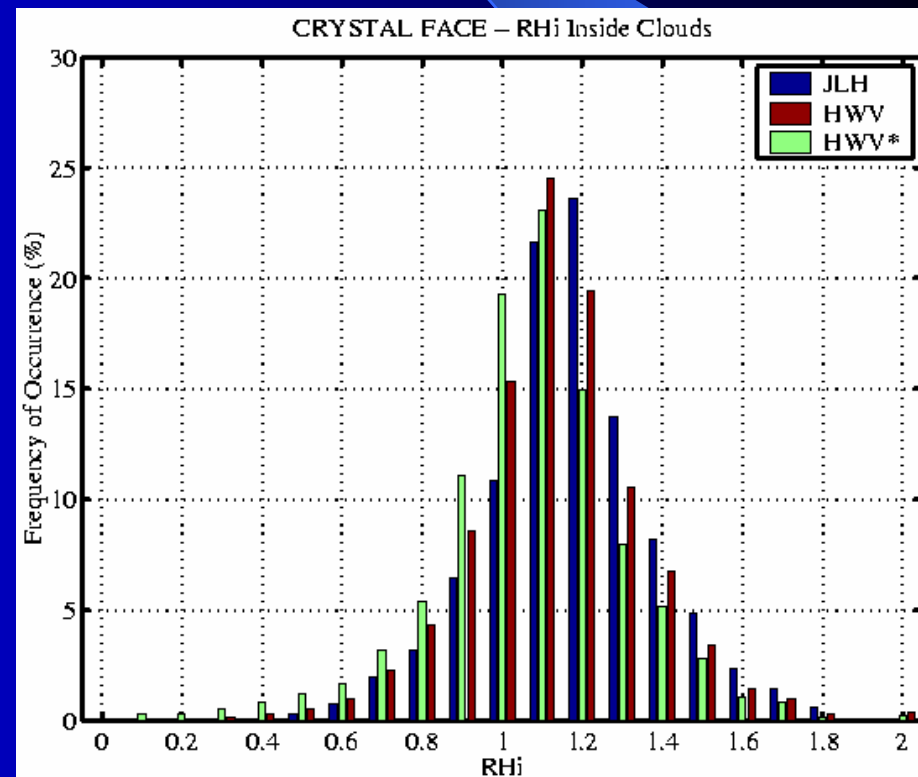
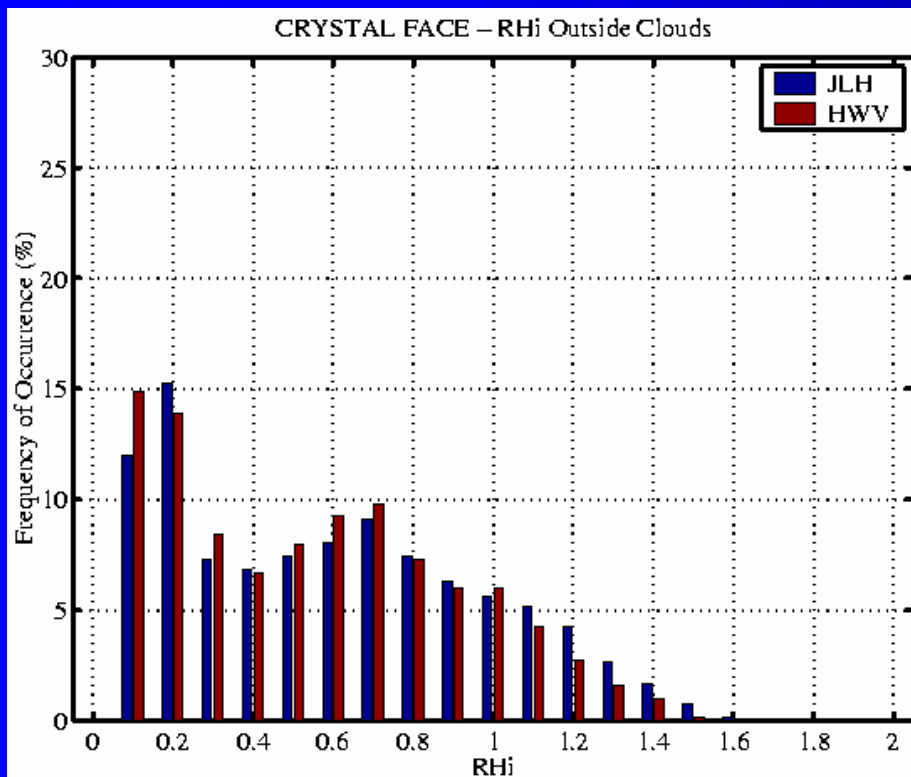
- Both water instruments experienced difficulties measuring water vapor reliably during cloud events.
- Inter-comparison with the JPL allows us to estimate the degree of sublimation $\rightarrow \sim 7.5\%$ of total ice water content.



Observations:

Supersaturation Frequently Observed in the Upper Troposphere

- We observe supersaturation both in clear air and in the presence of cirrus.



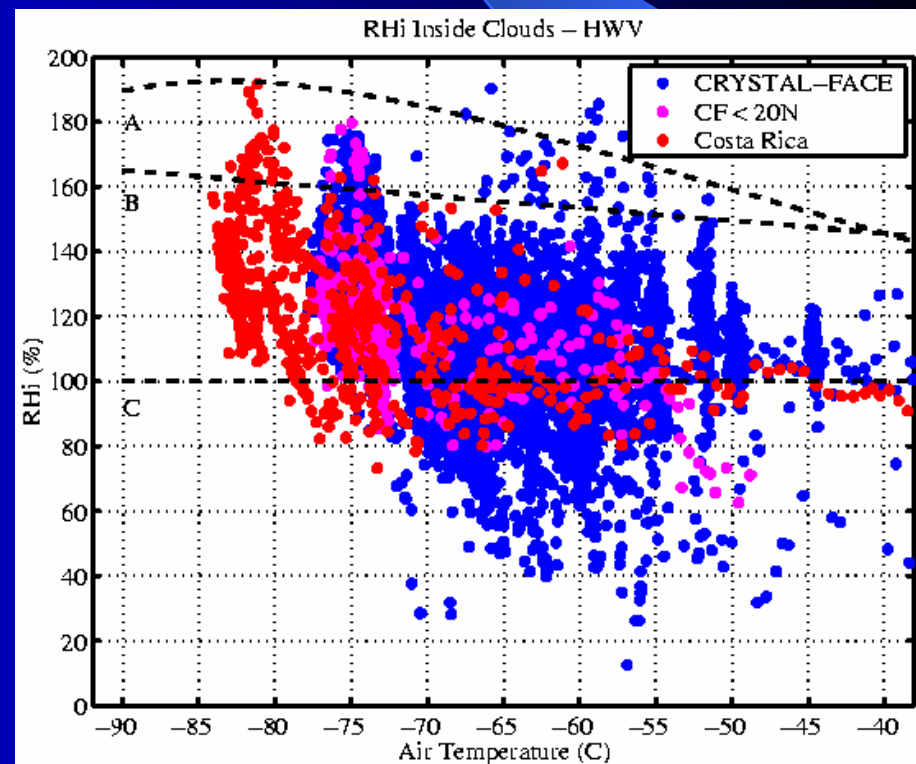
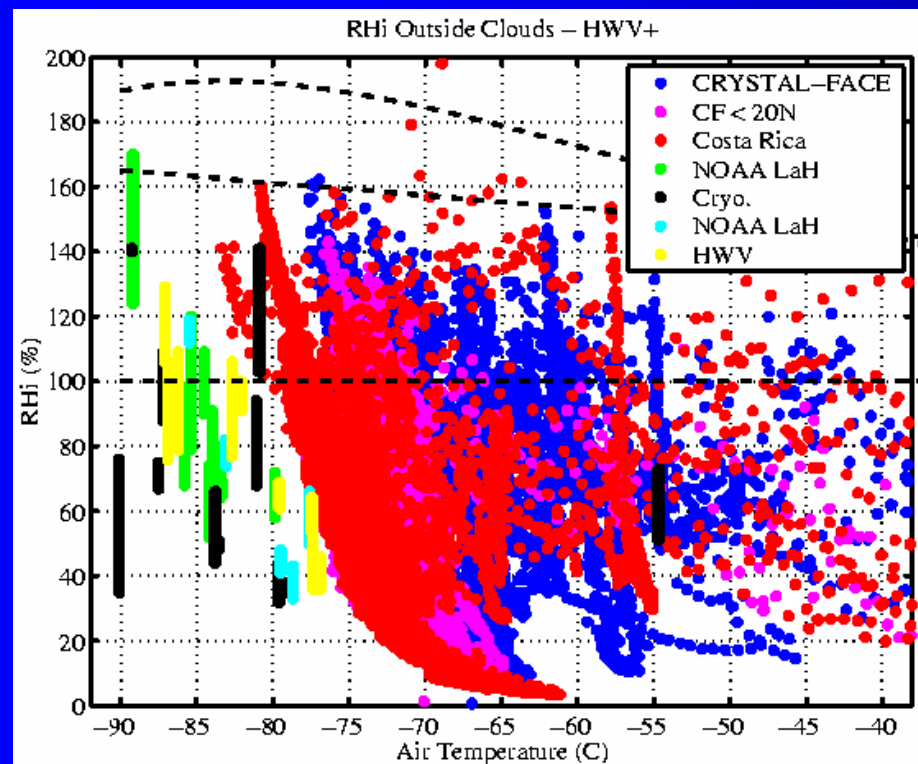
Supersaturation

- This is not the first time Supersaturations have been observed in the UT.
- In situ data acquired over the last few decades repeatedly show significant supersaturations inside as well as outside cirrus clouds.
(For example see Heymsfield et al., 1998; Gierens et al., 1999; Jensen, et al., 2001; Ovarlez, et al., 2002)

Supersaturation

The following figures show RHi's from the CRYSTAL-FACE data set in combination with data from the 2001 WB-57 mini-mission out of Costa Rica (August 2001), and UTT data compiled in Jensen, et al. 2001.

(Line A is the level of saturation with respect to liquid water; Line B represents the level of homogeneous nucleation; Line C is the equilibrium level of saturation with respect to ice.)



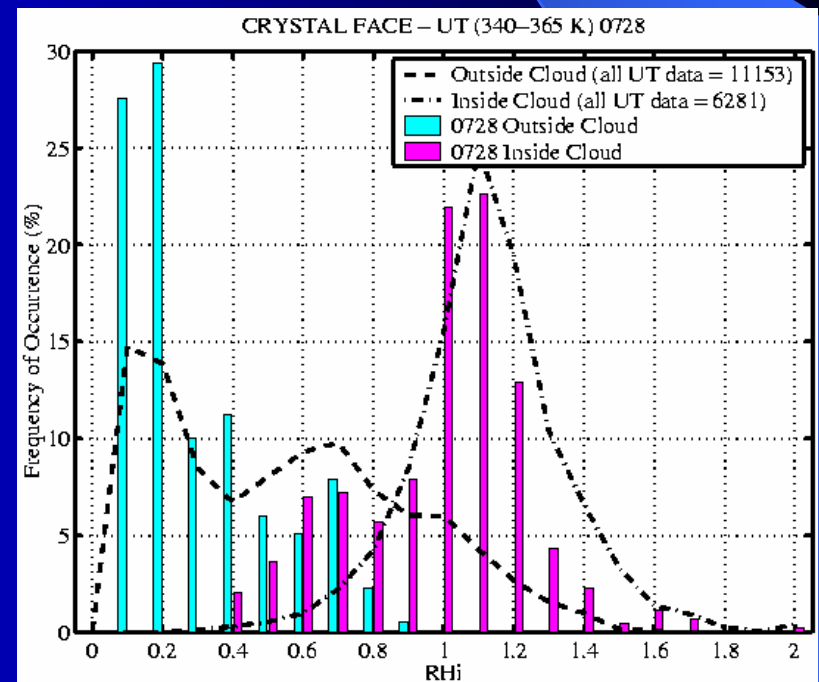
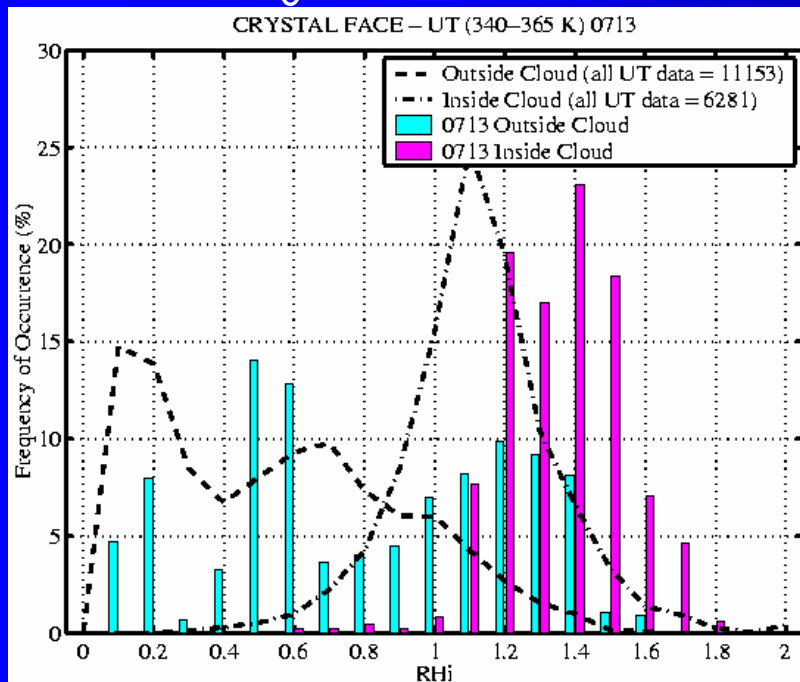
Future Work:

Missions to the Tropics:

More measurements in UTT

Case Studies in C-F data:

- 1) Contrail
- 2) July 13th – Thin cirrus, Tropopause cirrus
- 3) July 28th and 29th – Saharan Dust



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